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USE OF VERTICAL SLIP FLOW AND FLOODING MODELS IN LOCA ANALYSIS*

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Vertical slip flow and flooding models, which have been incorporated in a version of the RELAP4[1] computer code by Aerojet Nuclear Company have led to significant improvements in modeling nuclear reactor coolant system phenomena during postulated large and small break loss-of-coolant accidents. In previous versions of the RELAP4 code homogeneous one-dimensional flow was assumed in the development of the flow equations. Addition of the slip flow model allows the liquid and vapor phases to have unequal velocities and leads to improved energy transfer between control volumes. In addition, the slip model, when combined with the bubble rise model, eliminates vapor-mixture layering that previously occurred in vertically stacked control volumes. In conjunction with flooding correlations the slip model provides a reasonable approach toward modeling flow behavior in the downcomer during ECC delivery and during periods of reversed vapor flow in the core.

The vertical slip flow model computes the separated fluid component velocities and directions at vertical flow junctions. Use of the slip model allows the energy transfer between volumes to be based on individual liquid and vapor component flows rather than on the net junction flow. Continuity and momentum equations are unaffected by the addition of slip. The vertical flow slip model logic is based on the assumption that gravity forces dominate causing slip between phases. The slip velocity is defined as $V_{slip} = V_{liq} - V_{vap}$ (positive downward). Through use of this slip velocity expression in conjunction with the continuity equation, logic was developed to determine the component flow directions at a vertical flow junction. The following

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three flow combinations are allowed:

a) cocurrent flow downward

b) cocurrent flow upward

c) countercurrent liquid flow downward, vapor flow upward.

This slip model is based on previous work by Battelle Memorial Institute[2] and is similar to the drift flux model recently presented by Kelly[3].

A variable slip velocity correlation which is a function of junction void fraction is currently used to compute slip velocities. To assure code stability a simple correlation was developed which was continuous over the range of void fractions from 0 to 1.0. The correlation is based on cocurrent and countercurrent bubbly flow data and on countercurrent annular air-water flooding data[4].

Wallis type flooding models requiring user supplied constants to be input to the code have been added to RELAP4 in order to obtain better predictions of ECC bypass and liquid penetration into the downcomer. Either the standard Wallis[5] or the Wallis-Crowley[6] correlation can be used to check for flooding when the slip logic has indicated countercurrent flow in the downcomer. The flooding correlation and the continuity equation are solved simultaneously to yield a slip velocity consistent with flooding.

The Wallis flooding model used in conjunction with the vertical slip model has been used successfully to predict the semiscale steam-water steady state countercurrent flow test data[7] as shown in Figure 1. The computed flow conditions at the junction of the downcomer and upper annulus fall on the Wallis type flooding curve specified by constants which were obtained from air-water flooding tests[4]. Recently the RELAP4 slip version was shown to provide excellent predictions for semiscale Mod-1 isothermal Test S-01-1.

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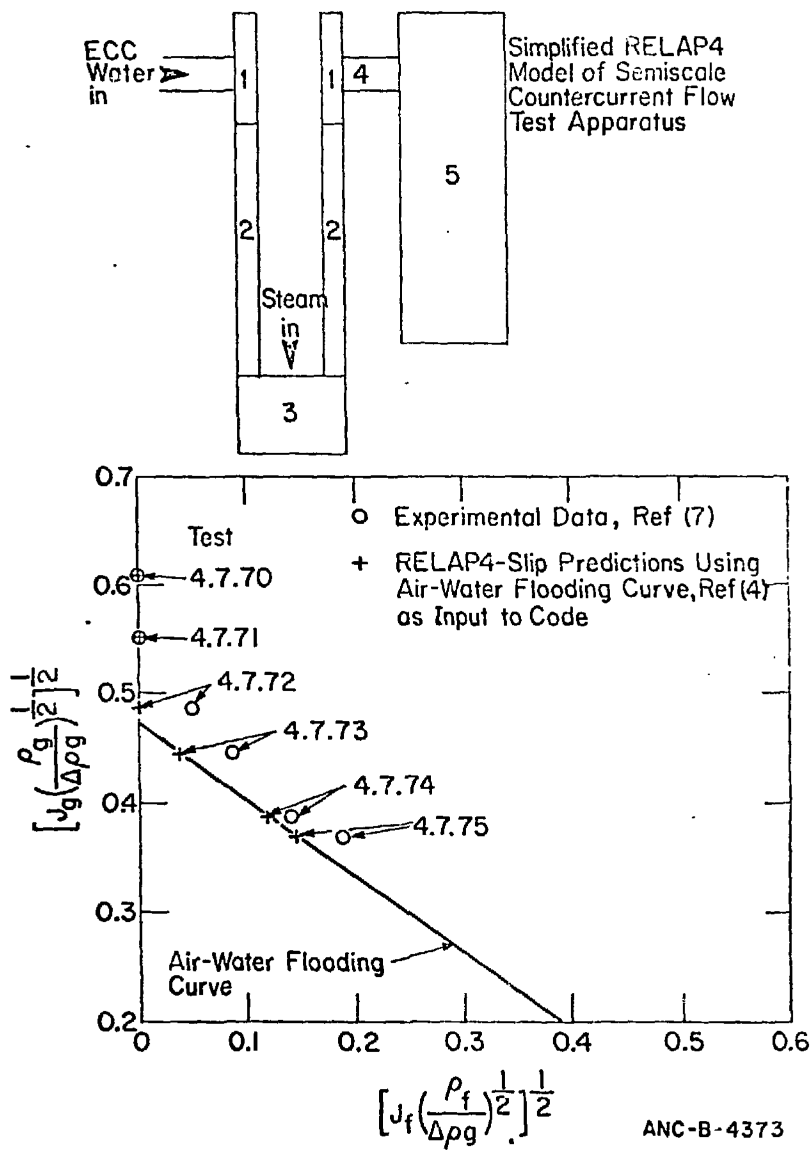

Fig. 1 RELAP4 Slip Predictions of semiscale Countercurrent Flow Test Series 4.7